



Democratising Research Practices through Community Citizen Science

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ABSTRACT

The involvement of the general public or volunteers in research has evolved over time. Terms such as ‘subjects’ have been replaced by ‘participants’ and are accompanied by an aspiration to actively engage people in research. Under the banner of Community Citizen Science (CCS), we have seen the public collecting or processing data to support activities led by professional scientists, while recently, we observed a growing interest in bringing together members of communities to examine personally relevant topics and identify solutions that best match their needs. In this study, we captured the perceptions of professional scientists about participants’ engagement in research activities. We interviewed 14 academics and researchers from The Open University UK who conduct primary research with human participants, including those explicitly involved in CCS and participatory research. We identified varied roles participants currently have in research, diverse perceptions about the benefits participants may experience from taking part in research, and challenges faced when certain forms of CCS are deployed. Insights from this study resulted in proposing a practical CCS framework with five functions that can enable the democratisation of research practices in the future.

CCS CONCEPTS

• Social and professional topics; • Professional topics; • Computing education; • Adult education;

KEYWORDS

Community Citizen Science, democratization, research practices, participants, higher education

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1 INTRODUCTION

Community Citizen Science (CCS) could be seen as the evolution of the concept of ‘public participation in research’ (Shirk et al., 2012);

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the term ‘citizen science’ has been used to denote the inclusion of the general public or non-professionals or volunteers in research practices and the production of scientific knowledge (Strasser et al., 2019). CCS is a more inclusive terminology in which all forms of ‘participatory approaches to science including scientist-led citizen science and community-led community science’ (Herodotou et al., 2022a, p.1) are encompassed. CCS differs from traditional research practices in which the role of participants is often limited to sharing their own data to support scientific inquiries. The aspiration of actively involving human participants in scientific activities is not a novel one, with the National Health Service (NHS) in the UK aspiring to ‘involving consumers in research not as ‘subjects’ of research, but as active participants in the process of deciding what research should take place, commissioning research, interpreting the results, and disseminating the findings’ (Boynton, 1998, p. 1521) and recent health approaches trialling ways methodologies such as focus groups can be democratised through co-production processes (Ledger, 2019).

There are different taxonomies describing volunteers’ participation in CCS mainly based on the task or tasks participants are asked to complete. Shirk et al. (2012) categorised CCS projects in: a) contributory: volunteers contribute or collect data, b) collaborative: volunteers collaborate with professional scientists beyond data collection such as informing the design of data collection protocols, and c) co-created: volunteers are involved in all stages of the scientific process. Haklay (2013) elaborated further this taxonomy to four levels of participation: Level 1 – volunteers as data collectors; Level 2 volunteers as data analysts; Level 3 - volunteers are defining a problem and a process of data collection; and Level 4 – ‘Extreme’ volunteers are involved in all stages of scientific research. It could be argued that one of the most demanding or challenging forms of CCS participation is co-created research or Level 4 – ‘Extreme’. Herodotou et al. (2017) with the notion of ‘Citizen Inquiry’ defined ‘Extreme’ forms of CCS as the ‘active engagement of the public in scientific activities that are not restricted to processes of data collection and analysis, and includes examples of citizen science projects initiated and implemented by volunteers. In citizen inquiry, the focus shifts from scientists to members of the general public as active agents who define their own research agenda underpinned by models of scientific inquiry, producing identifiable learning benefits.’ (p.2)

In addition, CCS could have three distinct purposes: ‘for research’, ‘for policy’ and ‘for society’. The first purpose relates to using CCS as a research method for scientific discoveries, mainly through the collection of big data sets. CCS projects mainly aim at contributing to science and are less concerned about volunteers’ learning or promoting democracy in research. The second purpose

refers to volunteers identifying and raising policy-related questions about complex and contested socio-scientific issues such as health and environment. The third purpose, triggered by community concerns and volunteers themselves, refers to 'mobilizing the community in collecting data in order to provide evidence to launch legal processes or influence political decision-making' (p.8) Scientific knowledge production can also be an output of such projects (Kasperowski et al., 2017).

Specific types of CCS share similarities with participatory action research (PAR). PAR is a collective methodology to research which involves people and communities in a process of reflection, data collection, and taking action in order to improve their own lives and reduce inequalities (Baum et al., 2006). PAR values participants' knowledge in their experiences and this is used to tackle problems and bring social change. Amongst the core elements of PAR are a process of building relationships with participants, establishing ways of working together and a common understanding of the problem under examination, collective gathering and analysis of data, and taking action (Cornish et al., 2023). PAR is closely related to 'Extreme' CCS or 'Citizen Inquiry' where participants are at the centre of the scientific process and their voices are considered in defining research objectives and determining processes of data collection and analysis. PAR is democratic in nature in the sense that those more likely to be affected by what is being studied are deeply involved in research. It could be argued that a notable difference between PAR and CCS is the emphasis of the former on action-oriented outcomes and of the latter on knowledge-oriented outcomes. In the case of PAR, researchers and communities act upon study results by changing community behaviours, laws, and policies (English et al., 2018). Some definitions of CCS align more closely to the 'action' element of PAR by emphasising collective action and research that brings solutions to societal challenges (Audubon Centre, 2018).

The CCS discourse often comes with a range of promises including 'democratisation, education, discoveries' (Strasser et al., 2019, p.52). It promises to transform science from a closed system accessible by a few professional scientists, to an open world where anyone can be educated and potentially act as a scientist contributing to scientific discoveries, thus 'democratising' science and research. This entails a re-distribution of power between professional scientists and volunteers. The degree to which power will be equally distributed depends on the level of volunteers' participation in CCS; participation in co-created CCS can have a greater impact on developing volunteers' confidence in their abilities to do research as opposed to participation in contributory projects (e.g., collecting data) (Clement et al., 2023). Strasser et al. (2019) critically analysed the democratisation argument by assessing the extent to which such aspirations reflect the reality of CCS projects. They noted two aspects: a) the demographics of CCS are not well captured and the few studies available point to a rather non-diverse set of volunteers taking part in scientific activities. CCS would be truly democratised should volunteers reflect diverse ages, gender, ethnicity, educational and professional backgrounds, and b) arguments about the number of volunteers signing up in CCS should be scrutinised as participation may vary from non-activity to actively being involved in a CCS project.

The ambition of democratising research practices through CCS should be discussed in relation to 'scaffolding' or available support that would enable volunteers to actively take part in research and consider themselves as able to collect and analyse data and define their own CCS project agendas. A study with 150 adult participants of a CCS online platform revealed that, although volunteers would be keen to take part in CCS projects designed by scientists, they perceived it as unlikely to co-create their own CCS projects due to a lack of skills, time, and support (Herodotou et al., 2022b). Technological advancements, such as the design of interactive web-based platforms, alongside the advent of Generative Artificial Intelligence (AI) could be of great value to CCS by helping volunteers develop necessary skills and provide ongoing and personalised support thus contributing to a wider public representation. Towards this direction, there are examples of online CCS platforms that offer guided support to volunteers to, for example, help them to analyse data (see www.zooniverse.org), collect and identify data with the help of AI and a community of volunteers (see www.inaturalist.org) and design and manage their own CCS projects through structured authoring processes and close collaboration with professional scientists (see www.nquire.org.uk).

1.1 Benefits from taking part in CCS

There is an increasing number of studies documenting benefits to volunteers from participating in CCS such as enhanced subject knowledge, development of scientific or research skills, greater awareness about the environment and in some cases changes to behaviour and habits (Aristeidou & Herodotou, 2020). These benefits have been mainly reported for adult volunteers, educated, white, middle aged and middle to upper class individuals (Blake et al., 2020). Fewer studies have examined the impact of CCS on other demographics such as young people and children (Herodotou et al., 2023).

The question raised is whether CCS programmes are designed with the intention to achieve specific benefits for volunteers or whether reported benefits are rather side products of the process. In the 'Ten Principles of Citizen Science', Robinson et al. (2018) refer to benefits for both professional and citizen scientists, as distinguishing factors between CCS projects and other types of research activities: 'Both the professional scientists and the citizen scientists benefit from taking part. Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence, for example, to address local, national, and international issues, and through that, the potential to influence policy.' (p. 29) A review of 120 English language CCS project descriptions revealed that while scientific goals, such as data collection, were clearly stated in 82% of the projects, social goals such as education and public discussion were rarely mentioned in 25% of projects. Similarly, social impact was only mentioned in 20 of the 120 projects referring to e.g., use of data in environmental education. Mentioning any benefits of participation for volunteers was completely ignored in 79 projects; only 15.8% of reviewed projects mentioned benefits such as generic learning and access to results (Golumbic & Oesterheld, 2023). Further attention should be given to articulating learning

and other benefits for volunteers and ensuring that these form part of the design and implementation of a CCS project.

Towards this direction, a detailed examination of young people's participation in blended CCS programmes on the citizen science platform iNaturalist revealed that specific tasks can bring up specific learning outcomes for volunteers. For example, the desire to become a scientist was related with young people engaging in observing and identifying species in nature, while increased scientific competence was related to recording species and communicating with volunteers and program facilitators (Herodotou et al, 2023). These findings suggest that, in order to achieve specific benefits for volunteers, these need to be considered from the outset and form part of the design and preparation of a CCS programme. Existing biodiversity frameworks could guide CCS designers by showcasing which participation activities are likely to bring up specific learning outcomes for volunteers (ibid).

1.2 Democratisation of research through CCS

CCS can play a transformative role in democratising research practices. By definition, CCS is inviting participation of the general public, including diverse populations, no matter their scientific background, to contribute to science. This means that scientific knowledge is not constructed or produced solely by professional scientists and that participation in scientific inquiry is open to potentially anyone. Scientific findings can thus become more transparent and accessible to the wider public (Irwin, 2018), potentially bridging the gap between research and society and enabling redevelopment of trust in science (Kurtulmus, 2021). The degree to which the ambition for inclusion has been achieved is still questionable as volunteers are found to have specific characteristics representing only a section of the general public (Strasser et al. 2019). Also, participation of future citizens in CCS, that is of children and young people, is currently shown to be limited and not well supported (Herodotou et al., 2023).

Democratising research through CCS can also have a positive impact on the future of science and scientific discovery. CCS enables implementation of ambitious and resource-demanding projects such as taking videos of water flow or collecting water samples. Such research activities would be challenging for scientists to collect alone as they would require significant time and resources (Irwin, 2018). The need for collecting significant amounts of data to sufficiently study a phenomenon is becoming a reality by having networks of volunteers collaborating and sharing data such as documenting biodiversity across the world, monitoring water pollution, and conducting data analyses.

Herzog and Lepenies (2022) proposes a 'deliberative systems approach' as a means to leverage the democratic potential of CCS. This approach raises a number of issues not adequately addressed in CCS debates including 'which kinds of topics should be prioritized (and whether citizens should have a say in this), the connection to democratic practices more broadly speaking, the question of which citizens to involve, the question of how citizen science projects relate to political actors and/or social movements, the extent to which projects should be open to discuss normative and political questions at the intersection of science and society, or the question of which bigger vision for the relation between science and society underpins

citizen science.' (p. 491). A central argument is the need for CCS to promote epistemic justice and inclusivity and ensure volunteers are treated as equal partners in deliberation by asking questions, proposing their own research agendas, and arguing about relevant societal and policy issues. This goes beyond existing attempts to democratize research that rely 'on highly specific pregiven meanings, forms, and qualities of participation' and which are 'not endemic to deliberative/dialogic models of participation' (Chilvers & Kearnes, 2020, p.349).

The current state of CCS shows that most projects engage volunteers in data collection and data processing practices (Hecker et al., 2018). Co-created projects where participants contribute as co-researchers are still rare, and therefore little is known about 'best' practice in designing and delivering co-created CCS (Gunnell et al., 2021). In this type of CCS, volunteers (as co-researchers) and professional scientists collaborate to design and implement research. Of great importance is the fostering of an inclusive environment of communication where the concerns of citizens and local communities are detailed and considered. In practice, to achieve equitable collaboration, CCS needs to consider from the outset the use of participatory methods such as PAR as well as adopt a reflexivity approach (Hidalgo et al. 2021). Divergence and convergence are core elements of a successful process of communication amongst volunteers and between volunteers and professional scientists: as a starting point, co-researchers may work individually or in groups to define a problem, formulate research questions, detail a research design, and plan the data collection. Collective decision making can be achieved by presenting and selecting ideas through voting or other methods of consensus making (Hidalgo et al. 2021).

1.3 Aim and research objectives

The aim of this study was to capture the experiences and perspectives of professional scientists (academics and researchers) from an online and distance learning university in the UK, The Open University, conducting research with human participants in the form of CCS or participatory research and provide practical recommendations of how research practices should be democratised in the future. Specific Research Objectives (RO) were to:

RO1: Collect the views and opinions of professional scientists across The Open University UK about their research practices and experiences with human participants.

RO2: Capture how professional scientists engage with participants to do research.

RO3: Capture how professional scientists would like their research practices to evolve or change in the future.

RO4: Develop a framework of how research practices could be democratised in the future that would inform the specification of a university's Centre for Democratising Research through CCS.

2 METHODOLOGY

The sample of this study was purposive, selected based on whether participants were involved in any type of CCS and/or participatory research. It was initiated through authors' personal contacts and then followed a snowballing approach of participants introducing other researchers for the study. Fourteen (N=14) researchers from The Open University UK were interviewed. They were coming from

diverse disciplines including, science and technology (n=6), arts and social sciences (n=1), business and law (n=3), and wellbeing and education (n=4).

Data were collected through in-depth semi-structured interviews. An interview schedule was prepared and piloted with questions such as: Have you heard of or considered engaging with CCS in your research? What do you think are some benefits participants have from taking part in your research? Would you like to change the ways you engage with your participants in the future (assuming you had time, resources etc)? We intend to specify the requirements for a Centre for Democratising Research. What do you think the vision of this Centre should be? Ethical approvals from the university were gained before approaching participants. All participants consented in taking part in the study.

Collected data were transcribed and entered in NVivo for analysis. A thematic analysis approach was adopted as described in (Braun & Clarke, 2012). The first two transcripts were coded by both Author A and Author B to establish inter-rater reliability and agree on a set of themes to be used, and extended as needed, in the follow-up analysis. A few cases of disagreement were observed, and these were discussed and negotiated until agreement was reached. Then, Author B analysed and coded the remaining transcripts. The themes emerging from the analysis were as follows: a) Research activities with human participants, b) Benefits to human participants, c) The future of research with human participants, d) CCS challenges, e) Democratising research through CCS. These themes are analysed in the next section.

3 FINDINGS

3.1 Research activities with human participants

Participating scientists described their research activities with participants in a range of ways. Several of them pointed to the use of participatory research and co-created citizen science with populations such as indigenous communities for the examination of nature preserve and mental health (Interviewee 4), carers and older people “by supporting them find better ways to health and wellbeing” (Interviewee 1), migrants in terms of how they “might use mobile phones to support their language learning” (Interviewee 2), capturing the voices of children in research (Interviewee 3) and working with marginalised communities “using Raspberry Pi’s to provide computer networks to support education and mental health (Interviewee 2).

Other participants mentioned engaging with participants for prototype testing that is, how to refine and improve web-based platforms to make them appropriate and suitable for context (Interviewee 12), involving participants in developing university courses (Interviewee 13), setting up a centre for policing in which members decide on what activities research funding is spent on (Interviewee 7) and engaging participants as co-researchers, such as people with learning disabilities, helping them to develop research skills (Interviewee 5).

3.2 Benefits to human participants

Benefits to participants from taking part in research ranged between satisfaction from ‘being heard’ (e.g., during an interview) to developing participants’ research skills and identification of solutions

to solve their problems. Benefits were either immediate (during or after research was completed) or more long term. Immediate benefits included: a) knowledge exchange through ongoing communication of findings (Interviewee 11), collecting feedback from participants to inform the findings of a study (Interviewee 11), co-analysing of data with participants (Interviewee 11), b) Satisfaction from ‘being heard’ such as when children’s opinions are considered important in research and hence they are interviewed (Interviewee 3), c) a therapeutic value from taking part in certain CCS projects such as those asking participants to read a text or listen to a sound and then reflect on their experience (Interviewee 3), d) co-created CCS that enables participants to do their own personally relevant research, become aware of what research is, develop research skills and confidence, and propose and implement solutions that meet their needs (Interviewee 3).

Long-term benefits were implemented well after the actual research and data collection had been completed. They included: a) one way communication of findings through dissemination practices (Interviewee 14) such as via publications, blogs, emails, and project websites, b) the development of free tools made available to participants, as the result of research (Interviewee 2), and c) the design of better university courses when these are informed by participant (student) feedback (Interviewee 13). It could be argued that the degree or type of participants’ engagement in research is shown to associate with a different set of perceived benefits; for example, data sharing (e.g., interviewing) to being heard while taking part in a co-created project to development of research skills and opportunities to identify solutions.

3.3 The future of research with human participants

Interviewees stressed the need for more inclusive forms research in the future: “how it can be a more inclusive practice to engage those currently underrepresented” (Interviewee 5) as well as “humanising research” (Interviewee 1) by bringing participants on board who are not professional researchers. They went on to note that “research isn’t just for some people, and research findings aren’t just for some people” (Interviewee 7). Another interviewee explained that “democratic research means every stage of the research process [...], it means inviting contribution where possible at all the stages of research [...] I don’t mean that in a formal all the stages of research, I mean it much more informally” (Interviewee 7). This could be achieved if professional scientists were willing to apprentice others on how to do research: “It’s about experts being prepared to apprentice other individuals to enable themselves to do things” (Interviewee 7).

They also made a distinction between “citizen-led research” and “citizen-led problem solving”, the former focusing on volunteers involved in the generation of new knowledge and the latter on volunteers involved in research that aims to solve problems: “So ideally working in a community setting, you would spend a lot of time understanding what needs and ambitions and goals were from the community” (Interviewee 2). The use of “citizen-led research” may be less biased and more inclusive: “the connotation of science is usually perceived as the natural sciences [...] I would prefer a term like ‘citizen-led research’, which really does change

the emphasis and also opens up to beyond the natural sciences” (Interviewee 4). Finally, they stressed the importance of “enabl[ing] citizens to engage in research in resolving their own local challenges” (Interviewee 4).

3.4 CCS challenges

While there was a strong emphasis on how research could look like in the future (see 3.3), interviewees were also aware of how challenging this can be in practice. They identified seven challenges related to making research more inclusive and democratic:

- a) *Time demands*: tight timelines related to completing data gathering and analysis explained why some researchers stated that “we didn’t consider taking that approach” (Interviewee 8). Also, there is limited or no time to get to know and work directly with community members - noting that intermediaries such as NGOs (as gatekeepers) may be a way forward: “A really good idea in principle but in practice it may be difficult to achieve” (Interviewee 8).
- b) *Identification and selection of participants*: participants noted the difficulties of finding participants to work with them in this capacity (Interviewee 6), a conflict of interest when selecting participants that may skew results (especially when sample processes are based on convenience), and challenges in finding diverse participants beyond “the usual suspects or the loudest voices” (Interviewee 6).
- c) *Participants’ research skills*: Volunteers are likely to have limited knowledge and skills about research methodologies and therefore there is a need for finding and using the right tools and approaches to enable engagement. How volunteers are engaged matters to any future engagement and research findings: “Don’t make them sit down and watch a load of us boring academics do presentations” (Interviewee 5).
- d) *Power imbalances*: Volunteers are often not seen as fully equitable partners. There is often a power inequality between them and professional scientists: “[We] were being paid for our time, where they weren’t” (Interviewee 2). Also, the process of consulting should be respectful and meaningful “but not expecting them to carry the load of this thing” (Interviewee 3).
- e) *Development of trust*: Interviewees raised the issue of time needed to build rapport with particular groups (Interviewee 6) and simplifying research processes such as completing long ethic forms that can be off putting: “while those processes are meant to be more inclusive and protect the safety of participants, they can actually really be off-putting and make it harder for us to reach out to people” (Interviewee 6).
- f) *Communicating findings*: Interviewees noted the need and responsibility to explain research processes, strengths and limitations in ways that volunteers can understand: “one thing that came across really clearly was their knowledge [...] but their lack of confidence in their knowledge. . . So they all knew how to do different parts of the research process but they weren’t confident in doing it” (Interviewee 5).
- g) *Negative attitudes*: In some forms of research, there are additional attitudes one needs to consider and tackle such as

An enabling vision for democratising research practices

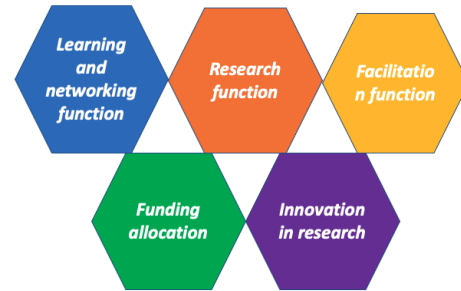


Figure 1: Five functions facilitating democratisation of research practices

in the case of research with children. As explained: “six-year-olds can’t take part in a focus group. . .you can ask their parents. . .[children] don’t really know what to tell you anyway” (Interviewee 3).

3.5 Democratising research through CCS

To identify specific recommendations of how research could be democratised, interviewees were asked to share their perceptions of what a “Centre for Democratising Research through CCS” should look like. Their recommendations emphasised the need for an “enabling vision”: “[a Centre should have] an enabling vision [...] providing tools, resources, platforms and. . .forums for engagement with each other for researchers who are interested in doing truly engaged research” (Interviewee 9). Another interviewee mentioned: “enabling people to participate and engage in research to the level that they wish to” (Interviewee 10).

This enabling vision could be operationalised through five functions (See Figure 1):

- a) a learning and networking function: “a space for people to come together to learn best practice and share practice and seek advice, so a network of peers. . .not just hearing about practice but an opportunity to generate future outcomes that benefit the network itself” (Interviewee 2). Also, another participant added: “the place where I can go for advice. . .in terms of recruitment, ethical research behaviour or inclusivity. . .able to lobby for me. . .I’m a young researcher or I’m from a minority or I have a brilliant idea but zero money. . .putting me in contact with a specific research community” (Interviewee 11).
- b) a research function: “recruit both citizens and scientists to undertake research that has the characteristics of participatory citizen science” (Interviewee 12) as well as “[help with] ethics processes and consenting participants” (Interviewee 6).
- c) a facilitation function: “we can find people for you from the general public, we can set up meetings between you [...] if it played the latter role, which is more facilitating and helping rather than simply telling people what they should do” (Interviewee 13).
- d) funding allocation: “have its own funding to distribute [...] and do a sort of mate matching programme” (Interviewee 11) as well as “a mechanism by which

anyone can vote for the projects that they think are important to be funded” (Interviewee 12). As explained further: “it might be because the project is addressing a particular problem and they are interested in solving that problem; but for others it might be because this project will support a researcher from an underrepresented community to solve a problem” (Interviewee 12). e) Innovation in research: As explained: “participant engagement in innovative ways, how you can actually really reach out to research participants ...not the usual suspects” (Interviewee 6).

4 DISCUSSION

The fourteen professional scientists who took part in this study were found to engage in a diverse set of research practices such as, collaborating closely with populations like indigenous communities, examining nature preserves, and addressing mental health issues. Some of them were also found to practice co-created forms of citizen science (Shirk et al., 2012) and follow principles of participatory research, involving active participation of non-experts in scientific endeavours. Amongst the populations they worked with were carers, migrants, children, and marginalised communities. These groups were engaged in research in different forms such as refining web-based platforms for context-specific suitability, co-designing university courses, influencing research funding decisions about policing issues, and being engaged as co-researchers fostering skill development and knowledge sharing. These insights showcase a range of ways volunteers are currently engaged in research from sharing their data to defining research agendas (Hacklay, 2013; Herodotou et al, 2017).

The forms of engagement with research were shown to relate to unique benefits for volunteers. For instance, collecting data from children through interviewing was seen as a means to ‘be heard’ whereas co-analysing data with participants as enabling enhanced engagement and motivation. These insights align with existing studies showing distinct learning benefits, especially for young people, depending on the type of participation or engagement in a CCS project (Herodotou et al, 2023) and suggest that to achieve certain benefits, a CCS project needs to be designed through considering how volunteers are expected to participate in a project. Overall, perceived benefits by professional scientists were grouped in immediate and long-term ones with the former referring to knowledge exchange regarding findings, influencing study outcomes, co-analysing data, ‘being heard’, therapeutic value from taking part in specific research projects, and empowerment from co-created forms of CCS. Long-term benefits referred to dissemination of findings, access to free tools, and improved future outcomes such as well-designed courses. Many of these benefits differ from proposed benefits as described in, for instance, the ten principles of citizen science (Robinson et al. 2018) where CCS is expected to have a substantial impact on participants’ engagement such as being involved in publishing research outputs, learning outcomes, social benefits and influencing policy. This may be a dimension of CCS that requires further attention aiming to raise awareness within professional scientists of ways volunteers may benefit from CCS.

To achieve a more meaningful knowledge creation in the future, professional scientists stressed the need for inclusive research practices that would engage under-represented groups in research and allow for non-expert researchers to engage in research. This ambition corresponds to a lack of diversity in terms of who is or can participate in research activities at the moment (Strasser, et al., 2019; Herodotou et al., 2022a). They also emphasised the need for a more ‘democratic research’ by inviting contributions from participants at all stages of the research process through close collaborations and partnerships. Democratisation of research was closely related to ‘Citizen Inquiry’ (Herodotou et al, 2017) or ‘Extreme’ (Hacklay, 2013) citizen science the vision of which is to enable active involvement of volunteers in all stages of research, from conception of a research question to data collection and analysis. There was also a distinction made regarding the purpose of CCS, ‘for research’ versus ‘for policy or society’ (Kasperowski et al., 2017), the latter tackling practical and local challenges. Such perceptions may contradict popular notions of citizen science as being ‘contributory’ that is set by scientists with volunteers collecting data (Pocock, et al., 2014). Defining what the purpose of a CCS project is can help professional scientists determine the role participants can play in it and how actively they can be engaged in research processes. For example, community-related CCS are likely to have a great relevance to communities as they relate to local concerns and hence volunteers may contribute to defining project objectives alongside data collection and processing activities.

Overall, democratization of research has been defined in terms: a) support to enable non-experts to engage in research, b) engaging under-represented groups in research, c) contributions of volunteers to all the stages of scientific research, and c) defining the purpose of CCS (for research, for policy, for society) that can determine the role volunteers may have in the process. This definition aligns with existing conceptions of democratization of science referring to opportunities for increased influence of the public on aspects of science and conditions that enable the public to understand how to promote their interests and values through participation in science (Kurtuluş, 2021). An important aspect of any definition produced is the language used to describe the engagement of volunteers in research. Such terminology should be, by definition, inclusive and not value laden. Terms such as ‘citizen inquiry’ (Herodotou et al., 2017) or “community inquiry” (Herodotou et al., 2021) may be appropriate to describe engagement in all stages of research, with the latter overcoming connotations related to what a ‘citizen’ means in different countries.

An inclusive and democratic approach to CCS, as described above, comes with significant challenges. It can be time demanding in terms of getting to know participants and implementing data collection processes - issues that seem to discourage professional scientists from taking up such an approach. The identification and selection of participants may be challenging with a major issue being the self-selected nature of sampling that often excludes representation of under-served communities. The research support provided to participants is a key aspect of a democratic CCS as without appropriate scaffolding, including teaching and learning about research practices, participants may not be able to contribute to research (Aristeidou et al., 2021). In addition, professional scientists should consider training themselves in different types of

CCS so they are able to identify ways to reduce power imbalances between professionals and volunteers, develop trust, communicate findings effectively, and change negative perceptions around the involvement of the general public in research. Power dynamics and 'unbalanced knowledge hierarchies' are often reported in citizen science projects as factors negatively affecting participation (Benyei, et al., 2023).

Despite the aforementioned challenges, CCS could be a suitable means for democratising research practices. As proposed by participating scientists, a dedicated 'Centre for Democratising Research through CCS' could help them to address proposed challenges. Such a Centre should have specific functions that operationalise and give guidance on how truly democratic CCS research can be done. It should have an 'enabling' vision and its activities should facilitate participation of the general public in research at desired levels. This could be achieved by providing a range of tools, resources, platforms, and forums for engagement between professional scientists and professional scientists and volunteers. In practice, it should serve five functions: a) enable learning, networking and sharing of best practices for professional scientists and the general public such as provide advice on recruitment, ethical research behaviour, inclusivity, and ways of connecting with minority backgrounds and other under-represented communities. b) facilitate ways of engaging with the general public through, for example, scheduled meetings and events, c) support research processes such as recruitment and ethics processes, d) allocate funding to support research activities as needed, and e) enable research innovation by, for example, identifying ways people from diverse backgrounds can be encouraged to take part in research. To the best of authors' knowledge, this is the first effort to operationalise the democratisation of research in the context of CCS by proposing tangible recommendations of how this can be initiated and supported by professional scientists within higher education institutions.

5 CONCLUSIONS

This paper stresses the importance of creating spaces for professional scientists to problematize and critically engage with current research practices. Such opportunities can help to establish just and democratic research processes (Martinez-Vargas, 2022). In particular, this study was an opportunity for 14 professional scientists to reflect on their current research practices, identify how they currently engage the general public in research and how this could be improved in the future to become more inclusive and democratic. Despite several challenges, professional scientists were willing to reconsider their research practices should support and guidance be in place. They stressed the demanding nature of activities that aim to democratise research and the need for resources, planning and ongoing support and structures in place, if this is to be achieved in the future.

Concerted efforts are needed to bring scientists (with and without expertise in CCS) together to share good practices and understand how they can democratize their research practices. There is also a need to build strong networks of ongoing communication and collaboration between professional scientists (e.g., Higher Education Institutions) and local communities in order for research to be grounded on local needs and for scientists to identify suitable

pockets of the general public for participation in research. What becomes critical is a good understanding of what makes people take part in research at different levels - from data sharing to co-designing research questions - and how they can be assisted in finding and taking part in research activities relevant to their needs, interests and commitments (Skarlatidou & Haklay, 2021).

In this paper, democratisation of research practices has been discussed in terms of how CCS projects should be designed in the future to engage with diverse populations, achieve intended or pre-considered benefits for volunteers, and promote active participation beyond data sharing, through data collection, data analysis and interpretation, and co-designing of projects with professional scientists. While documents such as the ten principles of citizen science (Robinson et al, 2018) are significant guides towards this direction, there is yet a need to operationalise CCS in terms of democratisation and identify ways challenges can be overcome and benefits can be realised. The practical framework proposed in this paper can be seen as a step towards defining how main actors in CCS can be supported to achieve a truly democratic vision of research.

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REFERENCES

- [1] Aristeidou, M., & Herodotou, C. (2020). Online citizen science: A systematic review of effects on learning and scientific literacy. *Citizen Science: Theory and Practice*, 5(1), 1–12.
- [2] Aristeidou, M., Herodotou, C., Ballard, H. L., Higgins, L., Johnson, R. F., Miller, A. E., ... & Robinson, L. D. (2021). How do young community and citizen science volunteers support scientific research on biodiversity? The case of iNaturalist. *Diversity*, 13(7), 318.
- [3] Audubon Center (2018). Why We're Changing From "Citizen Science" to "Community Science." Available online at: <https://bit.ly/3sf28ow> (accessed April 12, 2021).
- [4] Baum, F., MacDougall, C., & Smith, D. (2006). Participatory action research. *Journal of epidemiology and community health*, 60(10), 854.
- [5] Benyei, P., Skarlatidou, A., Argyriou, D., Hall, R., Theilade, I., Turreira García, N., ... & Woods, T. (2023). Challenges, strategies, and impacts of doing citizen science with marginalised and indigenous communities: reflections from project coordinators.
- [6] Blake, C., Rhanor, A., & Pajic, C. (2020). The demographics of citizen science participation and its implications for data quality and environmental justice. *Citizen Science: Theory and Practice*, 5(1), 21. pp. 1–10. <https://doi.org/10.5334/cstp.320>
- [7] Boynton, P. M. (1998). People should participate in, not be subjects of, research. *Bmj*, 317(7171), 1521.
- [8] Braun, V., & Clarke, V. (2012). Thematic analysis. *American Psychological Association*.
- [9] Chilvers, J., & Kearnes, M. (2020). Remaking participation in science and democracy. *Science, Technology, & Human Values*, 45(3), 347–380.
- [10] Clement, S., Spellman, K., Oxtoby, L., Kealy, K., Bodony, K., Sparrow, E., & Arp, C. (2023). Redistributing Power in Community and Citizen Science: Effects on Youth Science Self-Efficacy and Interest. *Sustainability*, 15(11), 8876.
- [11] Cornish, F., Breton, N., Moreno-Tabarez, U. et al. Participatory action research. *Nat Rev Methods Primers* 3, 34 (2023). <https://doi.org/10.1038/s43586-023-00214-1>
- [12] English, P. B., Richardson, M. J., & Garzón-Galvis, C. (2018). From crowdsourcing to extreme citizen science: participatory research for environmental health. *Annual review of public health*, 39, 335–350.
- [13] Golumbic, Y. N., & Oesterheld, M. (2023). From goals to engagement—evaluating citizen science project descriptions as science communication texts. *Frontiers in Environmental Science*, 11:1228480, 13pp. DOI: <https://doi.org/10.3389/fenvs.2023.1228480>
- [14] Gunnell, J. L., Golumbic, Y. N., Hayes, T., & Cooper, M. (2021). Co-created citizen science: challenging cultures and practice in scientific research. *Journal of Science*

- Communication, 20(5), 1-17.
- [15] Haklay, M. (2013). 'Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation'. In: *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*. Ed. by D. Sui, S. Elwood and M. Goodchild. Berlin, Germany: Springer, pp. 105–122. https://doi.org/10.1007/978-94-007-4587-2_7.
 - [16] Hecker, S., Garbe, L., and Bonn, A. (2018). *The European Citizen Science Landscape—A Snapshot*. London: UCL Press.
 - [17] Herodotou, C., Sharples, M., & Scanlon, E. (Eds.). (2017). *Citizen inquiry: synthesising science and inquiry learning*. Routledge.
 - [18] Herodotou, C., Scanlon, E., & Sharples, M. (2021). Methods of promoting learning and data quality in citizen and community science. *Frontiers in Climate*, 3, 614567.
 - [19] Herodotou, C., Ismail, N., Aristeidou, M., Miller, G., Lahnstein, A. I. B., Khanaposhtani, M. G., ... & Ballard, H. L. (2022a). Online Community and Citizen Science supports environmental science learning by young people. *Computers & education*, 184, 104515.
 - [20] Herodotou, C., Twiner, A., Scanlon, E., McLeod, K., & Seale, J. (2022b). From participants to creators: Considerations for community-led citizen science. *ICLS2022 Proceedings*. https://repository.isls.org/bitstream/1/8418/1/ICLS2022_11-18.pdf
 - [21] Herodotou, C., Ismail, N., I. Benavides Lahnstein, A., Aristeidou, M., Young, A. N., Johnson, R. F., ... & Ballard, H. L. (2023). Young people in iNaturalist: a blended learning framework for biodiversity monitoring. *International Journal of Science Education, Part B*, 1-28.
 - [22] Herzog, L., & Lepenies, R. (2022). Citizen science in deliberative systems: Participation, epistemic injustice, and civic empowerment. *Minerva*, 60(4), 489-508.
 - [23] Hidalgo, E., Perelló, J., Becker, F., Bonhoure, I., Legris, M., & Cigarini, A. (2021). Participation and co-creation in citizen science. Chapter 11. In: Vohland K. et al.(Eds). 2021. *The Science of Citizen Science*. Springer. <https://doi.org/10.1007/978-3-030-58278-4>. pp: 199-218.
 - [24] Irwin, A. (2018). No PhDs needed: how citizen science is transforming research. *Nature*, 562(7726), 480-483.
 - [25] Kasperowski, D., Kullenberg, C., & Mäkitalo, Å. (2017). Embedding Citizen Science in Research: Forms of engagement, scientific output and values for science, policy and society.
 - [26] Kurtuluş, F. (2021). The democratization of science. In *Global epistemologies and philosophies of science* (pp. 145-154). Routledge.
 - [27] Ledger, J. et al. (2019) 'O12 Democratising the research process: reflections on the co-production of focus groups', in *BMJ open*. London: BMJ Publishing Group LTD, pp. A5–A5. Available at: <https://doi.org/10.1136/bmjopen-2019-QHRN.12>.
 - [28] Martinez Vargas, C. (2022). *Democratising participatory research: Pathways to social justice from the south* (p. 260). Open Book Publishers.
 - [29] Pocock, M.J.O., Chapman, D.S., Sheppard, L.J. & Roy, H.E. (2014). *Choosing and Using Citizen Science: a guide to when and how to use citizen science to monitor biodiversity and the environment*. Centre for Ecology & Hydrology. https://www.ceh.ac.uk/sites/default/files/sepa_choosingandusingcitizenscience_interactive_4web_final_amended-blue1.pdf
 - [30] Robinson L.D., Cawthray, J.L., West, S.E., Bonn, A., & Ansine, J. (2018). Ten principles of citizen science. In S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel, & A. Bonn. *Citizen Science: Innovation in Open Science, Society and Policy*. London, UCL Press. 1–23.
 - [31] Shirk JL, Ballard HL, Wilderman CC, et al. (2012) Public Participation in Scientific Research: A Framework for Deliberate Design. *Ecology and Society* 17(2): 29.
 - [32] Skarlatidou, A. and Haklay, M. (2021). Citizen science impact pathways for a positive contribution to public participation in science *JCOM* 20(06), A02. <https://doi.org/10.22323/2.20060202>
 - [33] Strasser, B., Baudry, J., Mahr, D., Sanchez, G., & Tancoigne, E. (2019). "Citizen science?" Rethinking science and public participation. *Science & Technology Studies*, 32(2), 52-76.